CLAIMS:

1. A regenerative electrochemical cell system, comprising:

a fuel cell module comprising a fuel cell hydrogen inlet in fluid communication a hydrogen storage system, and a fuel cell oxygen inlet in fluid communication with both an oxygen source and with a gaseous portion of an oxygen/water phase separation device;

an electrolysis module comprising an electrolysis water inlet in fluid communication with the water storage device via the fuel cell module, and an electrolysis water outlet in fluid communication with a second water storage device.

2. A regenerative electrochemical cell system as in Claim 1, further comprising a hydrogen/water phase separation system comprising a fluid inlet in fluid communication with an electrolysis hydrogen outlet, and a gas outlet in fluid communication with a fuel cell hydrogen inlet, wherein said hydrogen/water phase separation system comprises an inverted hydrogen storage device.

3. A regenerative electrochemical cell system as in Claim 1, further comprising a heat exchanger disposed in fluid communication with the fuel cell module and the electrolysis water inlet, such that at least a portion of the water passing from the fuel cell module would pass through the heat exchanger prior to entering the electrolysis water inlet.

4. A regenerative electrochemical cell system as in Claim 3, wherein the heat exchanger comprises a radiator in thermal communication with a thermal load.

5. A regenerative electrochemical cell system as in Claim 4, wherein the thermal load comprises a building.

6. A regenerative electrochemical cell system as in Claim 1, further comprising a power source in electrical communication with the electrolysis module, wherein the power source comprises a power selected from the group consisting of solar power, hydroelectric power, tidal power, wind power, and combinations comprising at least one of the foregoing powers.

7. A regenerative electrochemical cell system as in Claim 6, further comprising a power conditioner electrically disposed between and in electrical communication with the power source and the electrolysis module.

8. A regenerative electrochemical cell system as in Claim 6, further comprising solar panels in electrical communication with the electrolysis module.

9. A regenerative electrochemical cell system as in Claim 6, further comprising a wind mill in electrical communication with the electrolysis module.

10. A regenerative electrochemical cell system as in Claim 1, further comprising a power conditioner electrically disposed between and in electrical communication with a power load and the fuel cell module.

11. A regenerative electrochemical cell system as in Claim 1, further comprising an oxygen vent in fluid communication with the oxygen/water phase separation device and a surrounding atmosphere.

12. A regenerative electrochemical cell system as in Claim 1, further comprising an operation device in operable communication with the system, wherein the operation device is selected from the group consisting of communication devices, control devices, and combinations comprising at least one of the foregoing operation devices.

13. A regenerative electrochemical cell system as in Claim 1, wherein the hydrogen storage system comprises storage selected from the group consisting of metal hydride and carbon based storage, and combinations comprising at least one of the foregoing storage.

14. A regenerative electrochemical cell system as in Claim 13, wherein the storage is in a form selected from the group consisting of particulates, nanofibers, nanotubes, and combinations comprising at least one of the foregoing forms.

15. A method for operating a regenerative electrochemical cell system, comprising:

starting up a fuel cell module by introducing feed hydrogen from a hydrogen storage system to a fuel cell hydrogen electrode and introducing feed oxygen from an oxygen/water phase separation device to a fuel cell oxygen electrode, and reacting hydrogen ions with the oxygen to generate electricity and fuel cell water;

once the fuel cell has attained operating conditions, ceasing the introduction of the feed oxygen, and introducing second oxygen from a surrounding atmosphere to the fuel cell oxygen electrode;

directing the fuel cell water to a water storage device;

introducing electrolysis water to an electrolysis water electrode, and introducing power to an electrolysis module, to produce refuel hydrogen and oxygen; and

directing the refuel hydrogen to the hydrogen storage system.

16. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising directing the oxygen to the oxygen/water phase separation device, and venting at least a portion of the oxygen from the oxygen/water phase separation device to the surrounding atmosphere.

17. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising cooling the fuel cell by directing coolant water from the hydrogen/water storage device through the fuel cell to the electrolysis water electrode.

18. A method for operating a regenerative electrochemical cell system as in Claim 17, further comprising removing thermal energy from the coolant water prior to introducing the coolant water to the electrolysis water electrode.

19. A method for operating a regenerative electrochemical cell system as in Claim 15, wherein the power is selected from the group consisting of solar power, hydroelectric power, tidal power, wind power, and combinations comprising at least one of the foregoing powers.

20. A method for operating a regenerative electrochemical cell system as in Claim 19, wherein the power comprises solar power.

21. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising separating refuel hydrogen and refuel water in the hydrogen storage system, and wherein the hydrogen storage system comprises an inverted hydrogen device.

22. A method for operating a regenerative electrochemical cell system as in Claim 21, wherein said hydrogen storage device further comprises a combined liquid-gas connector in fluid communication with the fuel cell hydrogen electrode.

23. A method for operating a regenerative electrochemical cell system as in Claim 21, wherein said hydrogen storage device further comprises a gas connection, and a gravity liquid connection.

24. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising directing at least a portion of the refuel hydrogen through a hydrogen/water phase separation device and into the fuel cell module as the feed hydrogen.

25. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising directing the electricity through a power conditioner and to a power load.

26. A method for operating a regenerative electrochemical cell system as in Claim 25, wherein the power load is a commercial load selected from the group consisting of telecommunications, computers, individual businesses, office parks, cable, and combinations comprising at least one of the foregoing commercial loads.

27. A method for operating a regenerative electrochemical cell system as in Claim 25, wherein the power load is a residential load is selected from the group consisting of individual home(s), neighborhood(s), village(s), and combinations comprising at least one of the foregoing residential loads.

28. A method for operating a regenerative electrochemical cell system as in Claim 25, wherein the power load comprises a power grid.

29. A method for operating a regenerative electrochemical cell system as in Claim 28, further comprising operating the system based upon electricity needs of the power grid.

30. A method for operating a regenerative electrochemical cell system as in Claim 29, further comprising directing the electricity to a local power load and reducing grid power to the local power load.

31. A method for operating a regenerative electrochemical cell system as in Claim 30, further comprising re-directing grid power to a remote power load.

32. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising supplying at least a portion of the feed hydrogen to an external hydrogen consuming device.

33. A method for operating a regenerative electrochemical cell system as in Claim 32, wherein the external hydrogen consuming device comprises a vehicle.

34. A method for operating a regenerative electrochemical cell system as in Claim 33, further comprising introducing make-up water to the water storage device from a continuous water source.

35. A method for operating a regenerative electrochemical cell system as in Claim 32, wherein the external hydrogen consuming device comprises an appliance.

36. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising introducing make-up water to the water storage device from a continuous water source.

37. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising introducing the feed hydrogen based upon a sensor signal of a cease in grid power.

38. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising commencing the introduction of the feed hydrogen based upon a sensor signal of a cease in grid power flow.

39. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising commencing the introduction of the feed hydrogen based upon a sensor signal of increased power demand over a predetermined amount.

40. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising commencing the introduction of the feed hydrogen based upon a sensor signal of operation for system testing.

41. A method for operating a regenerative electrochemical cell system as in Claim 15, further comprising remotely controlling the introduction of the feed hydrogen.

42. A method for operating a regenerative electrochemical cell system, comprising:

maintaining a fuel cell such that the fuel cell attains an operating temperature in less than or equal to about 1 minute;

introducing hydrogen to a fuel cell hydrogen electrode and oxygen to a fuel cell oxygen electrode;

forming hydrogen ions and electrons at the fuel cell hydrogen electrodes;

passing the electrodes through an external load to the fuel cell oxygen electrode; and

reacting the hydrogen ions with the oxygen at the fuel cell oxygen electrode to form water.

43. A method for operating a regenerative electrochemical cell system as in Claim 42, wherein the operating temperature is attained in less than or equal to about 30 seconds.

44. A method for operating a regenerative electrochemical cell system as in Claim 43, wherein the operating temperature is attained in less than or equal to about 15 seconds.

45. A method for operating a regenerative electrochemical cell system as in Claim 44, wherein the operating temperature is attained in less than or equal to about 1 second.

46. A method for operating a regenerative electrochemical cell system as in Claim 45, wherein the operating temperature is attained in less than or equal to about 40 milliseconds.

47. A method for operating a regenerative electrochemical cell system as in Claim 45, wherein maintaining the fuel cell further comprises heating the fuel cell.

48. A method for operating a regenerative electrochemical cell system as in Claim 45, wherein maintaining the fuel cell further comprises introducing the hydrogen to the fuel cell hydrogen electrode and the oxygen to the fuel cell oxygen electrode.

49. A method for operating a regenerative electrochemical cell system as in Claim 42, wherein maintaining the fuel cell further comprises applying an external voltage to the fuel cell.

50. A method for operating a regenerative electrochemical cell system as in Claim 42, wherein maintaining the fuel cell further comprises producing less than or equal to about 10 percent of nominal system power.

51. A method for operating a regenerative electrochemical cell system as in Claim 42, wherein maintaining the fuel cell further comprises producing hydrogen in an electrolysis module, recovering heat from an oxygen/water stream exiting the electrolysis module, and introducing the recovered heat to the fuel cell module.

52. A method for operating a regenerative electrochemical cell system as in Claim 42, further comprising introducing bridge power to the power load during fuel cell startup.

53. A method for operating a regenerative electrochemical cell system as in Claim 52, wherein the bridge power is supplied by a bridge device selected from the group consisting of a battery, a capacitor, a flywheel, and a combination comprising at least one of the foregoing devices.

54. A method for operating a regenerative electrochemical cell system as in Claim 53, further comprising generating electricity with the fuel cell and directing the electricity to the bridge device.

55. A method for operating a regenerative electrochemical cell system as in Claim 54, further comprising generating electricity with the fuel cell module for a sufficient period of time after the fuel cell module ceases supplying a power load to recharge the bridge device, and directing the electricity to the bridge device after a power supply from the fuel cell to a power load ceases.

56. A method for operating a regenerative electrochemical cell system, comprising:

introducing feed hydrogen from a hydrogen storage device to a fuel cell hydrogen electrode and introducing feed oxygen to a fuel cell oxygen electrode;

reacting hydrogen ions with the oxygen to produce water;

introducing an oxygen/water stream from the fuel cell oxygen electrode through a vortex tube to produce a hot stream and a cool stream, wherein the hot stream has a higher temperature than the cool stream;

introducing the cool stream to a phase separation device.

57. A method for operating a regenerative electrochemical cell system as in Claim 56, further comprising venting the hot stream to a surrounding atmosphere.

58. An electrochemical regenerative cell system comprising:

a first conduit in fluid communication with a hydrogen storage device and a dryer;

a first pressure regulator disposed in the first conduit between the hydrogen storage device and the dryer, the pressure regulator capable of reducing a pressure of a gas stream discharged from the hydrogen storage device to the dryer;

a second conduit in fluid communication with the fuel cell module and at least one of the hydrogen storage device and the dryer; and

a second pressure regulator disposed in the second conduit, wherein a pressure rating for the first pressure regulator is equal to or greater than a pressure rating for the second pressure regulator.

59. A method for operating a regenerative electrochemical cell system, comprising:

introducing water to an electrolysis water electrode and power to an electrolysis module, to produce refuel hydrogen and electrolysis oxygen;

directing the refuel hydrogen through a hydrogen storage system consisting essentially of a hydrogen/water phase separation device and an inverted hydrogen storage device, wherein the refuel hydrogen passes from the electrolysis module, through the hydrogen/water phase separation device, past a shut off valve, and into the inverted hydrogen storage device as dried hydrogen;

hydrating and fueling a fuel cell module by directing the dried hydrogen and inverted storage device water from the inverted hydrogen storage device through the hydrogen/water phase separation device, and to a fuel cell hydrogen electrode;

introducing feed oxygen to a fuel cell oxygen electrode; and

producing water and electricity.

60. A method for operating a regenerative electrochemical cell system, comprising:

introducing feed water to an electrolysis water electrode and power to an electrolysis module, to produce refuel hydrogen and electrolysis oxygen;

directing the refuel hydrogen through a hydrogen/water phase separation device and a dryer and into a hydrogen storage device at a pressure, wherein the dryer removes dryer water from the refuel hydrogen to form a dryer hydrogen;

hydrating and fueling a fuel cell module by reducing the pressure of the dryer hydrogen to a reduced pressure, passing the dryer hydrogen through the dryer, and removing dryer water from the dryer to form a hydrated hydrogen;

directing the hydrated hydrogen to a fuel cell hydrogen electrode of the fuel cell module;

introducing feed oxygen to a fuel cell oxygen electrode; and

producing water and electricity.

61. A method for operating a regenerative electrochemical cell system as in Claim 60, wherein the reduced pressure of the dryer hydrogen is about 2 psi to about 10 psi greater than an operating pressure of the fuel cell module.

62. A method for operating a regenerative electrochemical cell system as in Claim 61, wherein the reduced pressure of the dryer hydrogen is about 3 psi to about 7 psi greater than an operating pressure of the fuel cell module.